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An Integrated Xbee arduino And Differential Evolution Approach for Localization in Wireless Sensor Networks

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Abstract

Context aware or event based system requires location information of the event of occurrence. Sensor positioning and its location information are mandatory if a data sensed by the wireless sensor network (WSN) has to be meaningful. In cases like routing of packets of data in WSN, the dead sensor nodes should be avoided in the route. For this the location of live nodes is needed, so that the shortest and reliable routing is possible. Moreover some data require inherent location detection like forest fire detection or movement of miners in mines. So localization with better performance, with more reliability, with less computation complexity and lesser cost is much needed. This paper shows an integrated Xbee arduino and differential evolution approach for localization in wireless sensor networks, and the design of differential evolution localization algorithm for minimization of localization error. The algorithm is simple to implement and uses less control variables.

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Keywords: Differential evolution localization algorithm; Wireless sensor networks; Xbee arduino; Localization; RSSI; Mutation; Crossover;

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1. Introduction

Sensors are integral part of a smart, intelligent, and self decision making environment. These sensors in a group with particular topology and infrastructure forms wireless sensor network suitable for a particular application.WSN are extensively used in health monitoring, military surveillance, structural monitoring, road traffic management, precision agriculture, disaster management, forest fire detection, livestock monitoring and intrusion detection. Most of these applications demand self node localization which is a challenge in wireless sensor networks. Localization means location information of the sensor node or the device under consideration for monitoring. Global position system is not feasible for a energy constraint wireless sensor network and service may not be available at all places [1].

The proposed algorithm predicts the location information by using radio signal strength measurement between the location aware nodes known as landmarks and unknown location sensor nodes. Radio signal strength indicator (RSSI) is more sensitive to the environment. The battery of the transceiver also causes change in RSSI because of change in transmitter power and receiver gain. So provisions must be included to have RSSI error in tolerance limit [2].

Localization algorithm can be centralized or distributed. In centralized localization algorithm the location information is processed at the sink node or cluster head. This may require several hop of location data communication between sensor nodes and to the sink node. So centralized localization is complex, requires more energy, is less reliable but has more accuracy. Distributed algorithm on the other hand has difficulty in design. But in communication and energy constraint point of view distributed algorithm is better. And also the computation complexity increases exponentially as the number of sensor nodes increases in the case of centralized algorithm. Localization algorithm can also be categorized as range based and range free based algorithm. Range based depends on the estimation of the distance or angle between landmarks and sensor nodes. Range free method does not estimate the distance but needs beacon signals presence [3]

The aim of the paper is to design simple algorithm that requires less execution time, requires less memory space with better accuracy and reliability. This paper deals with range based distributed algorithm known as differential evolution localization algorithm for Xbee arduino based wireless sensor network. The algorithm uses Xbee arduino hardware setup for distance calculation between landmarks and sensor nodes using radio signal strength indicator (RSSI).The calculated distance is used by the differential evolution localization algorithm for the estimation of the location information of the sensor node.

2. The localization scenario

Four Xbee arduino are used, three as landmarks and one as sensor node. The location of the land marks is known. The location of the sensor node is not known and has to be estimated by the differential evolution localization algorithm. The RSSI received by the sensor node from the landmark is used to estimate the distance between the land marks and sensor node .This calculated distance is used by the differential evolution localization algorithm to estimate the location information of the sensor node [4].The Xbee is based upon IEEE 802.15.4 standard which needs less power and has low data rate with less cost[5].The RSSI measurement and distance conversion is done by the set up shown in figure 1.

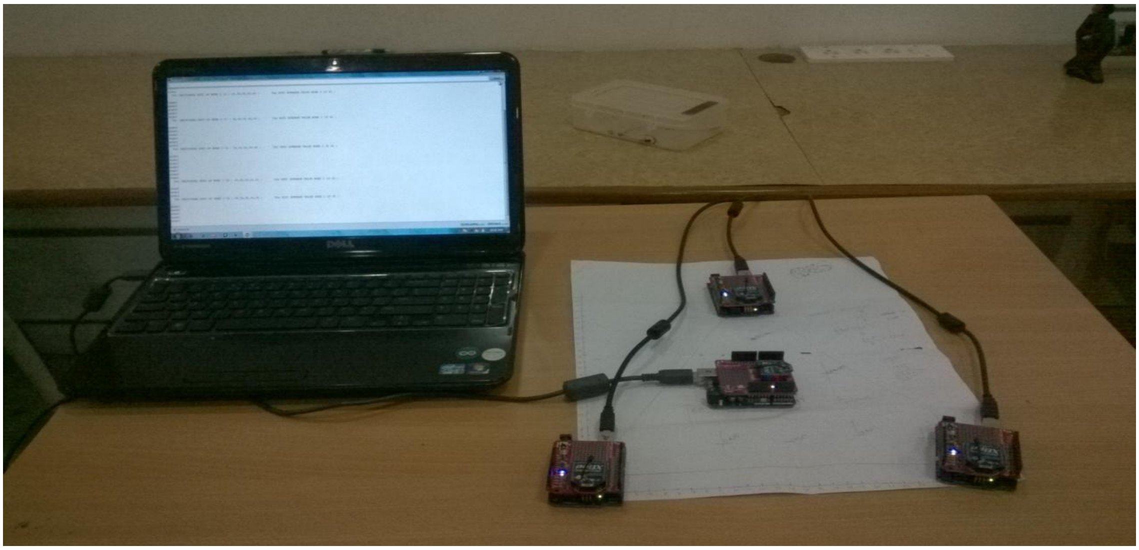


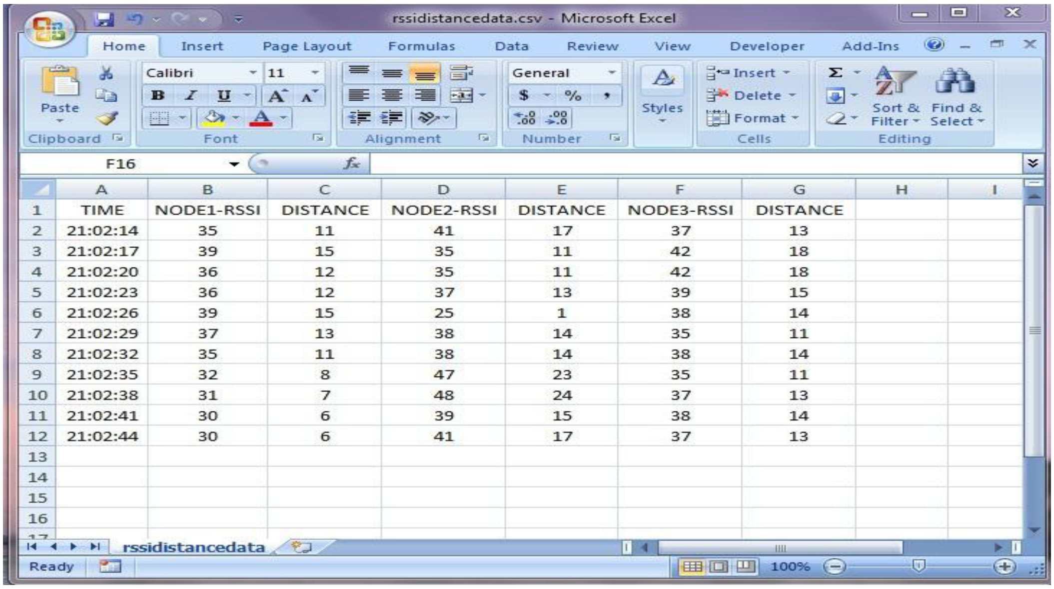
Fig. 1.Localization scenario setup

The distance conversion [6] is done by the equation (1)

$$d_{ist} = (R_s - R_o) * Cal \quad (1)$$

d_{ist} – distance between landmark and sensor node.
R_s – Received signal strength
R_o – Calibrated received signal strength
Cal – Calibrated value by experimentation

The RSSI value and the corresponding distance output of the hardware are shown in the figure 2.



TIME	NODE1-RSSI	DISTANCE	NODE2-RSSI	DISTANCE	NODE3-RSSI	DISTANCE
21:02:14	35	11	41	17	37	13
21:02:17	39	15	35	11	42	18
21:02:20	36	12	35	11	42	18
21:02:23	36	12	37	13	39	15
21:02:26	39	15	25	1	38	14
21:02:29	37	13	38	14	35	11
21:02:32	35	11	38	14	38	14
21:02:35	32	8	47	23	35	11
21:02:38	31	7	48	24	37	13
21:02:41	30	6	39	15	38	14
21:02:44	30	6	41	17	37	13

Fig. 2.RSSI value and the corresponding distance output of the hardware.

The differential evolution localization algorithm uses the output distance of the experimental set up, to estimate the location of the sensor node. Differential evolution is a stochastic search optimization algorithm that can be easily applied for experiment minimization problem. Differential evolution is parallel operable, flexible in implementation with less control parameters, and also has consistent convergence properties [7].

The basic operations involved in differential evolution localization algorithm are converting sensor node localization problem into differential evolution optimization problem, mutation, recombination or cross over and selection [8].

3. Differential evolution localization algorithm

The differential evolution localization algorithm has the following design procedure steps.
Step 1: The localization estimation variables are selected as particles of vector population and a vector population of 20 is taken.
Step 2: Initialize vector population in the solution space.
Step 3: Minimization of localization error is taken as the fitness function of differential evolution localization algorithm. The localization function is given by the equation (2)

$$f(X_u, Y_u) = \left[\sqrt{(X_{est} - X_{land})^2 + (Y_{est} - Y_{land})^2} - d_{ist}\right]^2 \quad (2)$$

X_{est}, Y_{est} is the estimated X and Y position respectively.
X_{land}, Y_{land} is the landmark X and Y position respectively.
d_{ist} is the distance between landmark and sensor node calculated from the RSSI value received by individual sensor node and anchor nodes.

Step 4: Based on the fitness value target vector is selected and mutated to get mutated vector using mutation process. In differential evolution localization algorithm mutation is given more importance compared to cross over. The mutation process equation is given by equation (3)

$$M_t^{mutated} = M_{best} + S * (T_V - R_V) \quad (3)$$

M_t = mutated vector
M_{best} = best optimal solution in the population
S = scaling factor = 0.7
T_v = target vector position
R_v = randomly selected vector position

Step 5: Cross over is done on mutated vector to get trail vector. Based on cross over constant CC=0.6, recombination process recombines either mutated or target vector variables. Cross over process is given by equation (4)

$$C^{trail} = \begin{Bmatrix} M^{mutated} if(rand) \leq CC \\ T^{target} if(rand) > CC \end{Bmatrix} \quad (4)$$

Step 6: Selection process decides target vector or trail vector for the next iteration. Target vector is replaced by trail vector if the fitness value of trail vector is greater than the target vector. The selection process is given by the equation (5)

$$S_P^{n+1} = \begin{Bmatrix} T^{trail} iff(trail) < f(target) \\ T^{target} iff(target) \leq f(trail). \end{Bmatrix} \quad (5)$$

Step 7: Repeat step 4, step 5, step 6 and step 7 till the stopping criterion that is the maximum iteration of 100 is reached.

Step 8: Estimate the optimal location information.

The differential evolution localization algorithm output for 100 iterations and 200 iterations are shown in the figure 3(a) and figure 3(b) respectively.

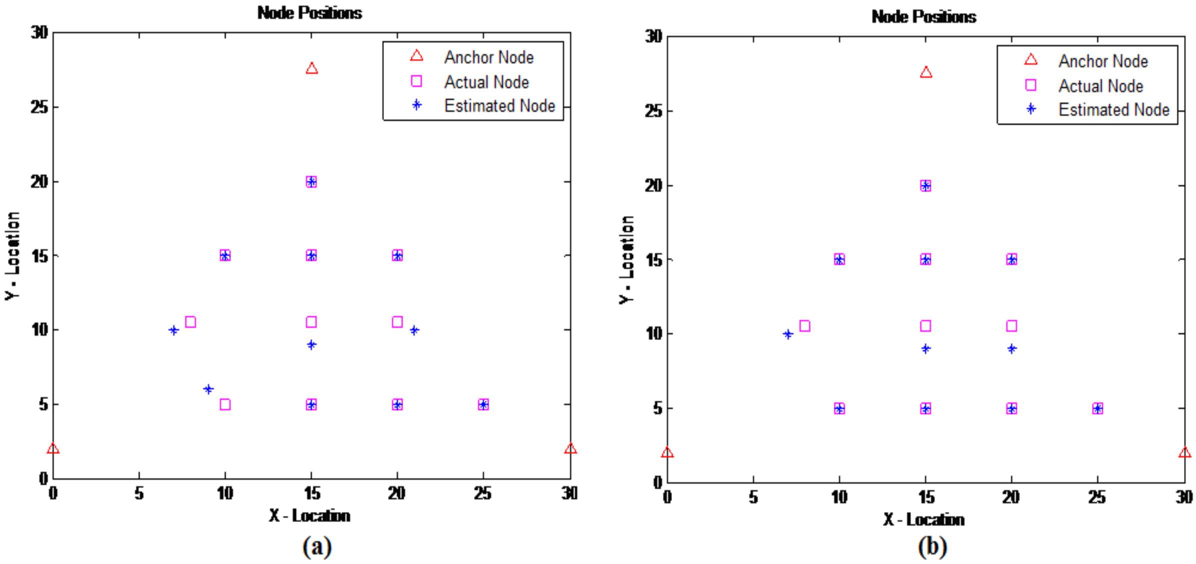


Fig. 3. (a) Output for one hundred iterations; (b) output for two hundred iterations.

The figure 3 shows that output of 200 iterations is better than 100 iterations of the differential evolution localization algorithm.

The convergence curve of differential evolution localization algorithm for 100 iterations and 200 iterations are shown in the figure 4(a) and figure 4(b).

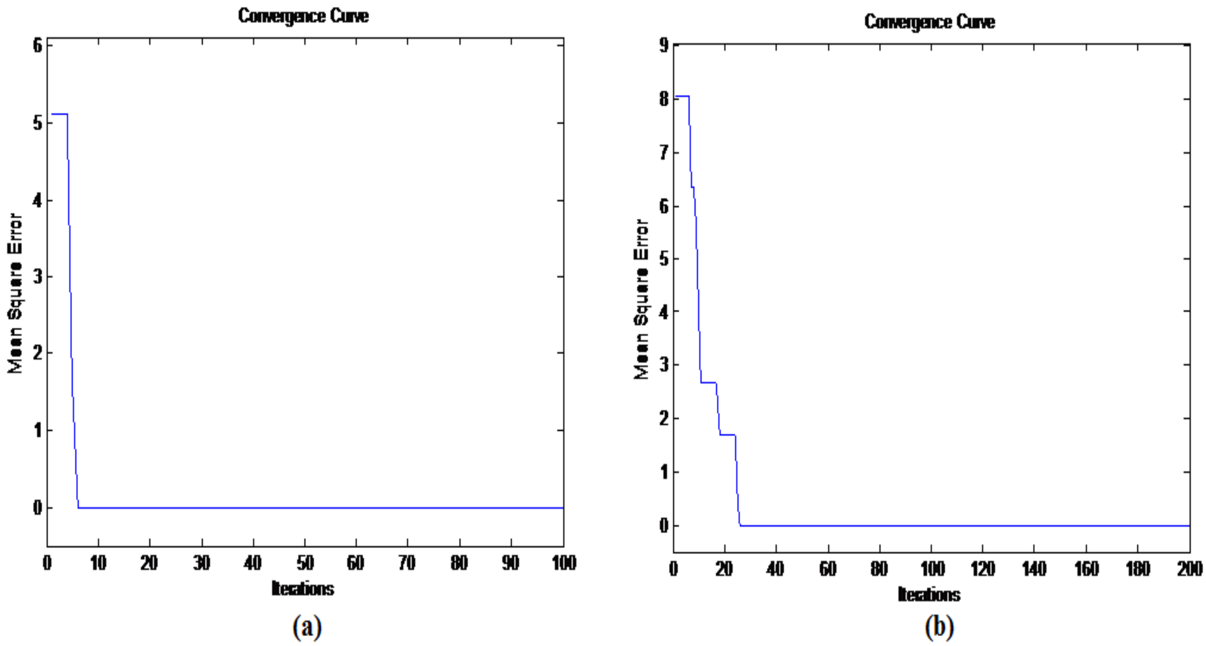


Fig. 4. (a) Convergence curve of for one hundred iterations; (b) Convergence curve of for two hundred iterations.

The figure 4 shows that convergence takes place at 6 th iteration and 22 nd iteration for 100 iterations and 200 iterations of differential evolution localization algorithm respectively.

Table 1 show the parameters used in differential evolution localization algorithm

Table 1.Design Parameters of Differential Evolution Localization algorithm

Parameters	Value
Space size	30
Landmarks	3
Unknown node	11
Total node	14
Number of vector population	20
Scaling factor, S	0.7
Cross over constant, CC	0.6

4. Conclusion

An integrated Xbee arduino and differential evolution localization algorithm for wireless sensor networks localization problem is introduced in this paper. This algorithm is range based and distributed, so it is much suitable for resource constraint wireless sensor network. The multi hop communication for location information is reduced, which increases the lifetime and reliability of wireless sensor networks. The algorithm is simple to implement and uses less control variables. The performance and accuracy can be further improved by reducing RSSI error by proper design and placement of sensor nodes. Further a hybrid algorithm may give better estimate of location information.

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